UTILIZATION OF RICE STRAW IN THE PRODUCTION OF SOME CELLULOSIC DERIVATIVES

Submitted By
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A thesis submitted in Partial Fulfillment
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The Requirement for the Doctor of Philosophy Degree
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APPROVAL SHEET

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Abstract

Egypt produces around 4 million tons of rice straw / annually. Fields must be cleaned from straw to make way for the next crop. Soil incorporation and field burning have been the major practice for removing rice straw. Field burning damage the land by killing useful microorganisms in the soil and incorporation in the soil is slower, more expensive and may promote rice diseases. The smoke from the rice straw combustions is also a potential health hazard for humans because it could give rise to asthma and cancer. Cellulosic compounds are the most important renewable natural resources on earth. Cellulose is the main component of plant cell walls, and the basic building block for many textiles and for paper. Cellulose is a hard crystalline material fibrous enough to use as paper, textiles, clothes, strings, sanitary goods, etc.. Cellulose is insoluble in water and most common solvents. Bonding between the individual chains prevents it from being broken by mild chemicals or water, and makes it resistant to enzyme decomposition. Hydrogen bonds, which give cellulose stability, are broken down through pretreatment methods by chemical reactions that take place in hydroxyl groups and glucosidic linkage of cellulose molecule. Cellulose has the ability to functionalize chemically to provide cellulose derivatives, such as cellulose esters and ethers which have important applications in our daily life such as in textiles, pharmaceuticals, food, and packaging industries. It is directly linked to the paper industry. Cellulose derivatives are further used as coatings, laminations, optical films and absorbents. Ionic liquids (IL) possess not only a high chemical and thermal stability, nonflammability and a negligible vapor pressure, but also the recycling of these solvents is comparably easy. Recently, certain ILs have been applied as green solvents which would dissolve cellulose and function as inert and homogeneous reaction media, found that the ionic liquids containing Cl^- have excellent capability to dissolve cellulose e.g.1-butyl-3-methylimidazolium chloride (BMIM)+Cl-. Cellulose solutions with up

to 25 wt% cellulose can be prepared using 1-butyl-3 methylimlidazolium chloride under microwave heating. Cellulose is precipitated easily using methanol, water or ethanol and the regenerated cellulose is rarely degraded and has polymerization degree and polydisperity that is close to the initial cellulose.

In an attempt to take advantage of agricultural waste such as rice straw, which causes an environmental problem, it was used as a cellulose source with ionic liquid, which can be recovered after the reaction, into cellulose derivatives such as methyl cellulose, carboxymethyl cellulose and hydrogel preparation of derivatives. Derivatives and hydrogels were used as additives to the pulp during the paper preparation process with other additives. The mechanical and optical properties of the resulting paper were studied. The experiments showed an improvement in the mechanical and optical properties of the resulting paper. The study showed that the water absorption rate in the paper was increased with the addition of both MC and CMC to reach 230 and 290%, respectively. On the other hand, addition of both MC-hydrogel and CMC-hydrogel produces absorbed paper with water uptake till 773 and 600%, respectively which means obtaining high absorbent paper.

Keywords: Rice straw – Ionic Liquid – Cellulose Derivatives

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List of Abbreviations

AGU	anhydro glucose unit
BC	bacterial cellulose
CMC	Carboxy methyl cellulose
DP	Degree of polymerization
DS	degree of substitutions
FT-IR	Fourier Transform infra red analysis
HEC	Hydroxy ethyl cellulose
IL	Ionic liquid
MC	Methyl cellulose
MCC	microcrystalline cellulose
OD	oven dried
Rs	rice straw
SEM	Scanning Electron Microscope
TAPPI OM	Technical Association of the Pulp and Paper Industry - Official Method
t/a	ton /annum
t/ha	ton /hectar
UV	Ultra violet
V	volume
W	weight
Δ	heat

List of Symbols

(AMIM)Cl: 1-ally-3-methylimidazolium chloride

(BMIM)Cl: 1-butyl-3-methylidazolium chloride

$(C_6H_{10}O_5)_X$: CELLULOSE unit

CDI: N,N'-carbonyldiimidazole

CH_3: methyl

Cl^-: Chloride anions

CO_2 : CARBON DIOXIDE

CS_2**:** Carbon disulfide

$Cu(NH_3)_4(OH)_2$: copper ammonia solution

Cu (en) $(OH)_2$: copper ethylene diamine solution

DMSO: dimethylsulfoxide

DMF: dimethylformamide

DMA/LiCl: N,N-dimethylacetamide/lithium chloride

(EMIM): 1-Ethyl-3-methylimidazolium cation

[Emim] Cl 1-ethyl-3-methylimidazolium chloride

EMIM dicyanamide $(C_2H_5)(CH_3)C_3H_3N_2^+N(CN)^-_2$

H_2SO_4: Sulfuric acid

H_2O: water

H_2S : hydrogen sulfide

K Br: potassium bromide

KOH: POTASIUM HYDROXIDE

KPS: potassium per sulfate

Na^+: Sodium cations

Na Cl: Sodium chloride

NaOH: SODIUM HYDROXIDE

NH_4Br: Ammonium bromide

NMMO: N-methylmorpholine - N - oxide

-OH: hydroxyl groups

PF: paraformaldehyde

THF: tetrahydrofuran